FRANCIS HARVEY
Section Cartography and Visualization in Geography
Leibniz Institute for Regional Geography
University of Leipzig
**Email:** f_harvey@ifl-leipzig.de

**Francis Harvey** is Professor for Visual Communication in Geography at the University of Leipzig, Germany and Director of the Section Cartography and Visualization in Geography at Leibniz Institute for Regional Geography, also in Leipzig Germany. Previously he worked as an Associate Professor in the Department of Geography, Environment, and Society at the University of Minnesota, the University of Kentucky, University of Leicester, UK, and École Polytechnique Fèderal de Lausanne, Switzerland. He also has held several visiting faculty positions in Poland and Germany. His research addresses a range of central issues for Geographic Information Science and cognate fields including visualization, semantics, interoperability, overlay algorithms, institutional aspects, cadastral issues, and practical ethics. Harvey's book *A Primer of GIS* (Guilford Press) covers the use of evolving geographic information technologies and is widely used for undergraduate and graduate level courses in the United States and internationally. He is currently working on two large research projects and a number of institute projects.

# A Spatial Science Challenge: Scientific Geovisualization in the Age of Data

A long, long time ago (about 1980!), geographic discovery almost always involved a map in any discovery. People relied on prior symbolizations, usually published often quite expensive maps or collections of map limited by the size of the paper, the budget for printing and the geographic scale. Some especially knowledgeable people (geographers) with years and years of training became experts and trained others how to use these symbolic devices in their professional activities.

How has this changed! Jennifer Wing and Jim Gray point out many of these changes.

Now, any average internet user can craft a map from data (theirs or others) very fast and very easily—usually. There are many issues—some are scientific.

People in GIScience come from these challenges after decades of advances in working with maps in what was then called "promisingly analytical cartography." Now, challenges arise from working with data and ubiquity of map-making and analysis tools. People are more frequently constrained by the overwhelming amounts of data available for spatial analysis and representation. Discovery now is not just data-driven; it is data-based. People rely on geovisualizations, mostly still called maps, in terms of

their ability to process information. Visualization is no longer just a matter of making and understanding symbols, but far more a matter of working with data.

In this sense, what discovery now involves is radically different (see also Simon 1996 for an indication of the development already noted then). Whereas Hans Rosling could use his evocative presentation skills and beautiful animations to bring discovery with data to life, most of us spend lots of time merely wallowing through vast amounts of data to make sense of things. We might delight in a finished presentation, or another showcased geovisualization, but how discovery, or might we prefer to say now data exploration, in GIScience is changing with data-based approaches. At one of modernity high points, the artist Paul Klee, then at the Bauhaus in Dessau, Germany in the 1920s memorably stated that art is about "*making the invisible visible"* an understanding of graphic communication that connects well to the present. In a data-based approach, analytical visualization for exploration involves very often, as Georgia Lupi from Pentagram, highlights the importance of "*the data we do not see"* in a recent Museum of Modern Art DataViz exhibit and developing actionable insights.

Exploration, now, in other words, involves the challenge of learning to see data that we make through our filters of reality, that is crafted in those interactions,"human and algorithmic to help answer specific questions."

This data-based approach to knowledge will change how people come to approach scientific visualization. Human-Computer Interaction has gone beyond Bertin and his graphic variables to gain a better understanding of the processes of visual communication. Visualizations support our cognitive processes and help us think. For many kinds of analysis, they are easier and faster to process than numeric or textual information. (Tversky). Considering the simplicity of a geovisualization involves some consideration about science and its impacts. Tackling the challenges of spatial data visualization has begun already, but some issues need systematic scientific attention. Every visualization is spatial. However, what do we understand about this spatiality, which art history (and more recently geography) has lumped under matters of veracity, intertextuality, and semiotics? Beyond cognitive visualization research, a vast literature about graphic communication exists, that GIScience has only partially tapped into. Connecting the spatiality in geocommunication with cognitive spatiality is an crucial issue. I would want to point out three exemplarily domains to develops with others into a fully-fledged research program. The first research topic is how people make sense of geovisualizations. We understand that a graphic is not necessarily geographic, but it is spatial. How we understand the spatiality of data representations of geographic data and develop insights, speaks to cognitive, preattentive, as well as spatial thinking matters (Harvey, 2017). The other research topic nestles under arc between Barry Smith's work on ontologies and Luciano Floridi's levels of abstraction, organization, explanation, and conceptual schemes. A broad topic that Werner Kuhn Semantic Engineering) points to in terms of conceptual clarity as a matter of, in my words, defining our terms for science and engineering purposes and grounding them in the reality of a situation. This approach

moves into considerations of information-age positions such as Object-Orientated Ontology, actornetwork theory, social cognition as we move to engage our conceptual frameworks for developing GIScience and applying it.

Jill Larkin and Herbert Simon (1987) set out a number of points about the efficiency of humans or machines processing graphic representations with their interactions for interpretation. Key to graphic presentations of any information is location, which following Larkin and Simon, create and constrain the relations that can express meaning. In a bar chart, with its established conventions location/relations perform specific functions. In a geovisualization, the functions usually involve a generative graphic techniques facilitated by the creator and processed by the user. The result is knowledge, but as we are still uncertain about how the mind makes sense of graphics, the relation between data and knowledge is of central importance for efficient processing.

Johanna Drucker considers the persistent issue, since at least Aristotle, how images show reality. Linda Kurgan approaches the pragmatical issues arising for science in how we make data visible with the term para-empirics, which expresses that data is never facts, but only representations. Data opens up many ways to participate and engage in exploration. Algorithmic processing is a key part of this.

The grounding of data-based geovisualization in reality, fortunately, can turn to past analytical cartographic work as a starting point: Waldo Tobler, John Sherman, Helen Couclelis, Nicholas Chrisman, Alan MacEachren, Gennady Andrienko, Sara Fabrikant have pursued research and theoretical work that helps work through these matters with a clear connection to empirical research results and publishable studies. As visualization, with its symbolizations, is and will remain an essential part of the spatial data science agenda, taking this direction crafts a new path towards continuing the development of GIScience research and increasing its potential. For example, developing solutions with linked data using narrative approaches (Bodenhamer) can use on data-based visualization approaches to craft multi-perspective curated presentation (OnCurating) that facilitate science and help make the invisible visible and science more present and actionable.